Application of AHP in Selection of Wind Farm's Location

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Abstract

Wind power is one of renewable clean energy which has huge reserve. According to the relevant data, 1% of the wind resource on the earth will be able to satisfy the world's energy needs. In recent years, as the rapid development of China's wind power industry, wind farm site selection has also become an important research subject. This article is based on the AHP model to analyze the many indicators which impact on the wind farm site selection.

Keywords

Wind Resource; AHP; Wind Farm Site Selection

Introduction

With development of China's wind power industry, wind farm site selection has also become an important research subject which is related to two kinds of factors on economic benefits and social benefits. It includes 10 indicators of wind resource, the local ecological environment, climatic conditions, terrain conditions and so on. This article is based on the AHP model analyzing many indicators and to evaluate the importance of the indicators which impact on the wind farm site selection. Through exports discussion and investigation work on the patent technologies of wind power, we get the diagram of the final hierarchy and the final judgment matrix. And after calculating the maximum eigenvalue of the judgment matrix, we conclude that the matrix satisfies consistency.

Ahp-Based Mathematical Model and Algorithm

AHP is a decision-making method, which is consist of qualitative and quantitative analysis. Firstly, according to problem nature and aim, it will get the main factors to solve the problem .Then based on the relationship among the factors, It constructs a hierarchical model, which is divided into the target layer, rule layer, and project layer. Finally, by estimating the importance of the various factors in hierarchy structure, it will give the importance weights of the project layer to the target layer. That is the order of project layer.

Construct of the Hierarchical Structure

According to our country's actual situation of wind farm construction, ten indicators will affect the location of wind farm. The ten indicators can be classified into economic and social benefits of wind farm construction. Next, we will carefully introduce several major factors:

1) The Wind Resource

The richness of wind energy is the basic condition of wind farm construction. In China, the rich wind resource areas include the Three-North (Northeast, North, Northwest) area, coastal area and island area, etc.

2) The Local Terrain Conditions

The local terrain also must be taken into consideration. In china, mountains occupy 70% of land. So even between two adjacent places, the wind direction and strength is often very different. Therefore, the site should be chosen in the area that has the high average wind speed.

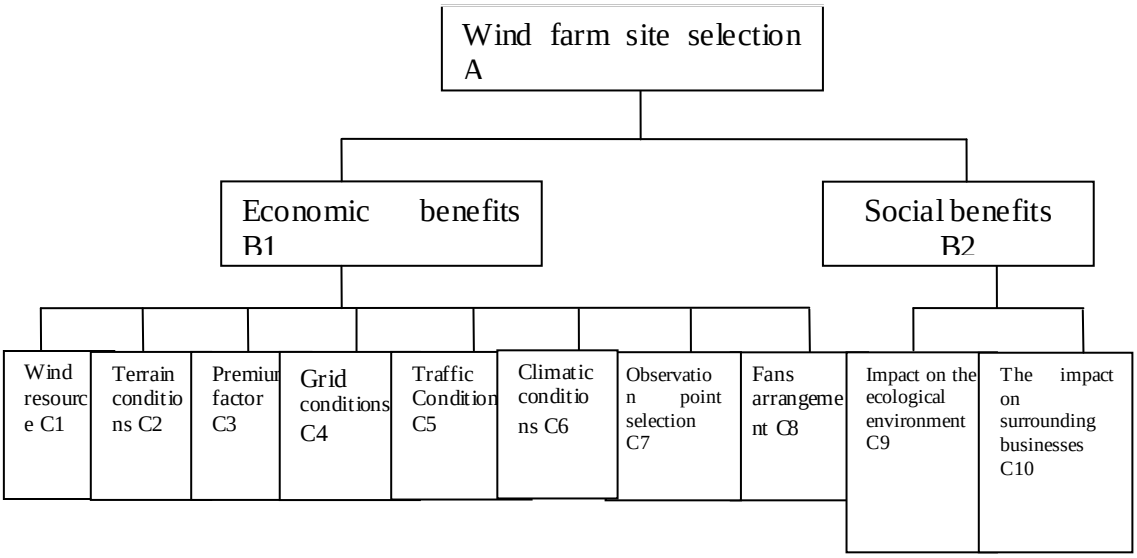
3) Climatic Conditions

Some of the meteorological phenomenon would be catastrophic threat to the structure of wind power. Although some weather conditions can not trigger catastrophe, they can increase maintenance costs, shorten equipment life.

4) The Observation Point Selection

The observation point selection of wind energy is closely related to the accuracy of the wind energy and wind turbine control. In general, the instability of wind energy in waters observation points is small, the mountain observation points have a certain instability, while the suburban observation points have greater instability.

TABLE 1 DIAGRAM OF THE HIERARCHY



5) The Impact on the Ecological Environment

Compared with coal-fired power plants, wind power plants achieve zero emissions to the atmosphere, but it should keep an appropriate distance with local resident to reduce the noise. It should be kept away from natural reserve, avoiding to destroy farmland and forest.

We will get the following diagram of the final hierarchy:(Table1)

Judge Matrix Structure Construction

Using back and forth expert research method on wind power relevant experts, we can get the final judgment matrix as follows:

(Table 2-4)

TABLE 2 GOAL LAYER JUDGMENT MATRIX (A)

A	B1	B2
B1	1	3
B2	1/3	1

TABLE 3 ECONOMIC BENEFITS JUDGMENT MATRIX (B1)

B1	C1C1	C2	C3	C4	C5	C6	C7	C8
C1	1	5	6	3	6	5	8	9
C2	1/5	1	2	1/3	2	1	4	5
C3	1/6	1/2	1	1/4	1	1/2	3	4
C4	1/3	3	4	1	4	3	6	7
C5	1/6	1/2	1	1/4	1	1/2	3	4
C6	1/5	1	2	1/3	2	1	4	5
C7	1/8	1/4	1/3	1/6	1/3	1/4	1	2
C8	1/9	1/5	1/4	1/7	1/4	1/5	1/2	1

TABLE 4 SOCIAL BENEFITS JUDGMENT MATRIX (B2)

B2	C8	C9
C8	1	5
C9	1/5	1

Single-level Sorting and Consistency Check
Single-level Sorting

This paper is used square root method on single-level sorting, following these steps:

Supposing Judgment Matrix:

$$A=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

We calculate the product of each row in judgment matrix

$$M_i = \prod_{j=1}^{n} c_{ij}, \quad i = 1,2,\ldots\ldots,n$$

Calculate the nth root of M_i***:***

$$\overline{W_i} = \sqrt[n]{M_i}$$

Normalize the vector

$$\overline{W} = (\overline{W_1}, \overline{W_2}, \ldots\ldots, \overline{W_n})^T$$

$$W_i = \overline{W_i} \Big/ \sum_{i=1}^{n} \overline{W_i}$$

$$\overline{W} = (\overline{W_1}, \overline{W_2}, \ldots\ldots, \overline{W_n})^T,$$

it is the eigenvector corresponding to the largest eigenvalue.

Then we can calculate the maximum eigenvalue of the judgment matrix.

Consistency Test

Consistency test can test the consistency of experts in critical thinking.

Consistency test are as follows:

Consistency index: CI=(λmax-n)/(n-1),

The average random consistency index RI is as follows:

1	2	3	4	5	6	7	8	9
0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Calculate the consistency ratio: CR=CI/RI

When it is CR <0.1, we think that the consistency of the matrix is acceptable; When it is the CR≥ 0.1 ,the consistency of Judgment matrix is poor, and there is a logical error. we make appropriate amendments to the Judgment matrix until the matrix has satisfactory consistency, then get the eigenvector W that is the index weights.

Applied to this article, the comparison judgment matrix A is calculated as follows:

W=（0.75 0.25）^{T} λ_{max}=2 CI=0

Therefore, we believe that the consistency of judging matrix is satisfied.

For the comparison judgment matrix B1, the results are as follows:

W= （ 0.388396 0.104487 0.065358 0.219406 0.065358 0.104487 0.03061 0.021897 ）^{T} λmax=8.303684 CI=0.030768

RI =1.41; CR=0.030768 < 0.10 ,

We also believe that the consistency of judging matrix is satisfied.

For the comparison matrix B2, the calculated results are as follows:

W=（0.8333333 0.1666667）T

λmax= 2

CI=0

CR=0< 0.10 ,

Therefore, we think that judgment matrix has the satisfying consistency.

According to above results, we can conclude that the matrix satisfies consistency, so that the obtained eigenvector W that is the index weights.

The total level sorting and consistency test

	B1	B2	Ranking
W	0.75	0.25	
C1	0.388396	0	0.2912969
C2	0.104487	0	0.0783653
C3	0.065358	0	0.0490188
C4	0.219406	0	0.1645546
C5	0.065358	0	0.0490188
C6	0.104487	0	0.0783653
C7	0.03061	0	0.0229576
C8	0.021897	0	0.0164227
C9	0	0.833333	0.2083333
C10	0	0.166667	0.0416667

And because:

CI=0.75×0.030768+0.25×0.00=0.023076

RI =0.75×1.41+0.5×0.00=1.0575

CR= 0.0218213 < 0.10

Therefore, we believe that the consistency of judgment matrix is satisfied.

Conclusions

Analyzing above results, we can conclude that the wind resource is still the most fundamental and important energy. Secondly, we should consider the impact on the local ecological environment. With rapid development of the wind power industry in China, it is clear that experts are increasingly focusing on this indicator while previous selection only paid attention to economic benefits. But now experts start to accept

that economic and social benefits are equivalent in importance. Then we consider the grid conditions, which is the main factor affecting the economic benefits of wind farm operation. Next, we should take climatic conditions, terrain conditions and so on into account. Finally, I expect to do modest contribution for the wind farm site selection by this paper.

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